



Ecosystem Dynamics



Henry Vanderploeg
Program Leader



Ashley Elgin



Reagan Errera



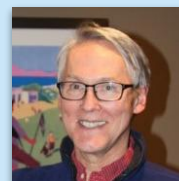
Doran Mason



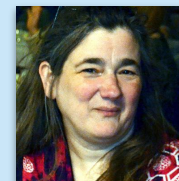
Steve Pothoven



Mark Rowe



Ed Rutherford



Rochelle Sturtevant
Michigan Sea Grant



Casey Godwin
Cooperative Institute for
Great Lakes Research

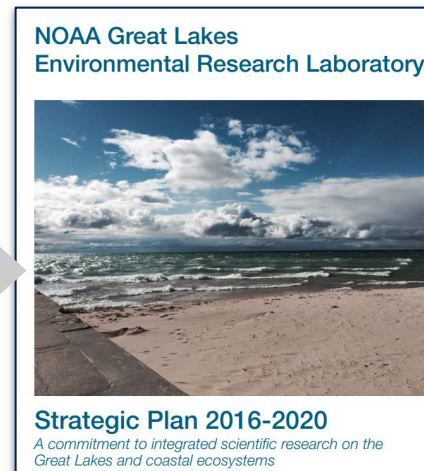
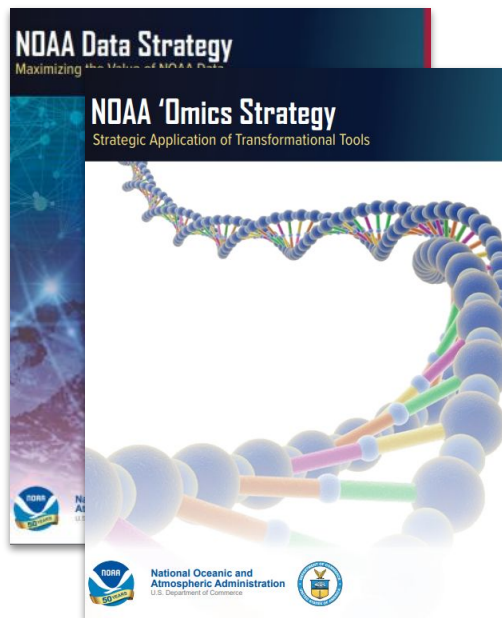


NOAA GLERL's Freshwater Ecology Mission

The Ecosystem Dynamics (EcoDyn) branch strives to monitor, analyze, understand, and predict changes in Great Lakes and coastal ecosystems to strengthen capacity for managing water quality, fisheries, invasive species, and ecosystem health.



EcoDyn addresses issues identified in NOAA's research plans and guiding documents.



EcoDyn Guiding Principles and Goals pp. 29-30.



Goals and Strategic Objectives pp. 15-19

Delivering NOAA's future

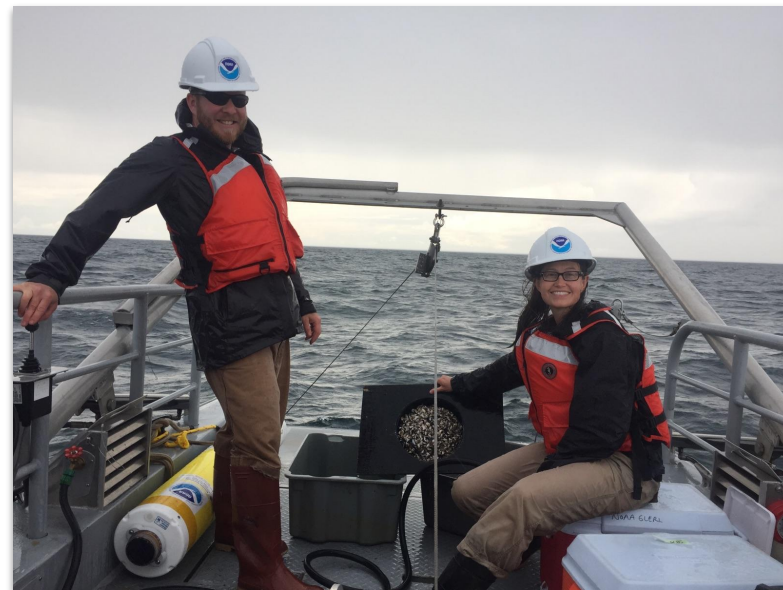
See review website "Documents" tab for more.

Conducting research to understand the physical, chemical, and ecological processes that affect the Great Lakes system.

Quantifying measurements of important ecosystem variables, at appropriate time and space scales, to serve as a basis for describing and understanding ecosystem processes.

Complementing observations with experiments and models for understanding the dynamics of Great Lakes and coastal ecosystems.

Developing forecasts and applications that are built on a solid foundation of empirical observations, experimentation, and understanding.



NOAA GLERL scientists Ashley Elgin and Paul Glyshaw on a Cooperative Science & Monitoring Initiative cruise for a Lake Huron quagga mussel growth experiment (June 2017).



Focusing on priority ecological problems, and their interactive effects, in the Great Lakes and coastal ecosystems.

Invasive Species - The economic and ecological health of the Great Lakes continues to be threatened by the impacts of invasive species, including zebra mussels, quagga mussels, and invasive carps. Over 180 nonindigenous species have been reported to have reproducing populations in the Great Lakes basin.

Nutrients - Nutrients impact the Great Lakes in two general ways- too much and not enough. Increased loading has resulted in the reduction of water quality and led to the formation of Harmful Algal Blooms (HABs) and hypoxia in some Great Lakes embayments and in Lake Erie. In the more oligotrophic Great Lakes basins, sequestering of phosphorus nearshore by mussels is reducing offshore productivity and causing the potential collapse of the offshore fisheries.

Climate Change - A warming climate is transforming abiotic factors (e.g., temperature, precipitation) that can impact habitat and food webs.

Sharing EcoDyn expertise through collaborative field campaigns.

- Collaborative efforts around the Great Lakes region
- Work with OSAT to develop, modify, and apply technology
- Work with IPEMF to develop biophysical models

Long-Term Research Program - Collect and understand critical food web variables in nearshore and offshore Lake Michigan for the development of new concepts, models, and forecasting tools to explore impacts of various stressors on the ecosystem.

Spatial Cruises - Define and understand spatial interactions of nutrients and food-web components from microbes to fishes, and their consequences to food web production

Harmful Algal Bloom (HAB) monitoring - Develop understanding of drivers of HAB dynamics for development of tools to predict spatial distribution, extent, seasonal dynamics and toxicity.

Coastal Hypoxia Research Program (CHRP) - Field observations quantify the physical and biochemical drivers of hypoxia and support development of a Lake Erie hypoxia forecast.

Inter-agency Cooperative Science and Monitoring Initiative (CSMI) - An international, multi-agency effort to study invasive species, water quality, fisheries, and climate change in all five Great Lakes—pursuing key knowledge gaps in the ecosystem change.



2020: EPA Bronze Medal, For work on the 2019 Lake Erie Cooperative Science and Monitoring Initiative Project.



Characterizing the Great Lakes Food Web: Long-Term Research Program

Steve Pothoven



Long-Term Research Program (LTR) on Lake Michigan makes seasonal observations of pelagic and benthic habitats of food webs in nearshore and offshore waters.

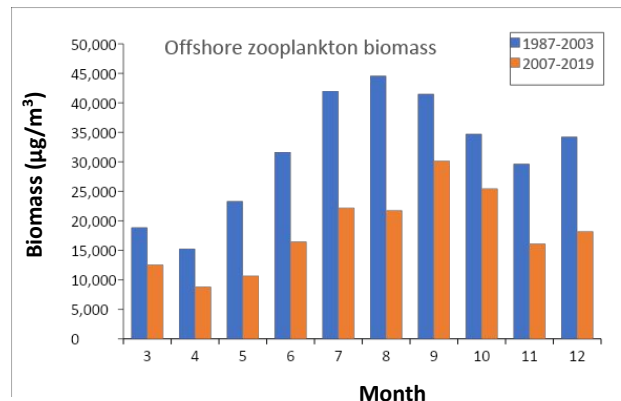
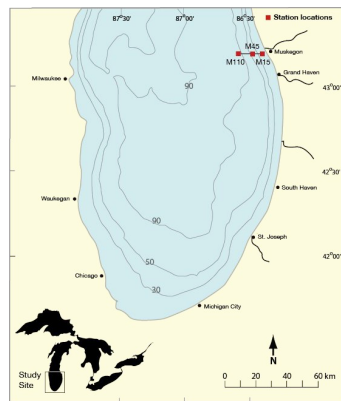
Integrates a core set of long-term observations on biological, chemical, and physical variables, accompanied by process studies and field experiments for understanding and forecasting ecosystem change.

Temperature, fluorometer, transmissometer profiles, nutrients, chlorophyll, zooplankton, *Mysis*, mussels and veligers, overwinter thermistor and fluorometer moorings.

March-December (as conditions permit)
1-2 times/month.

Serves as a baseline for process studies and model work.

16 Peer reviewed publications
2016-2020.



Journal of Great Lakes Research - Special Supplement - Complex interactions in Lake Michigan's rapidly changing ecosystem. Edited by **Henry A. Vanderploeg**, David "Bo" Bunnell, Hunter J. Carrick, Tomas O. Höök (November 2015)

Improving our understanding of the underlying mechanisms of fish recruitment in support of Great Lakes fishery.

Characterizing early life stages of key prey fishes that support important fisheries in nearshore and offshore habitats of Lake Michigan.

Work with federal, state, and tribal partners to identify early life bottlenecks for lake whitefish and develop predictors for their contribution to commercial fishery.

Provide up to date information on the lower food web that is used to help fisheries managers provide sustainable commercial and recreational fisheries through wise use of resources.

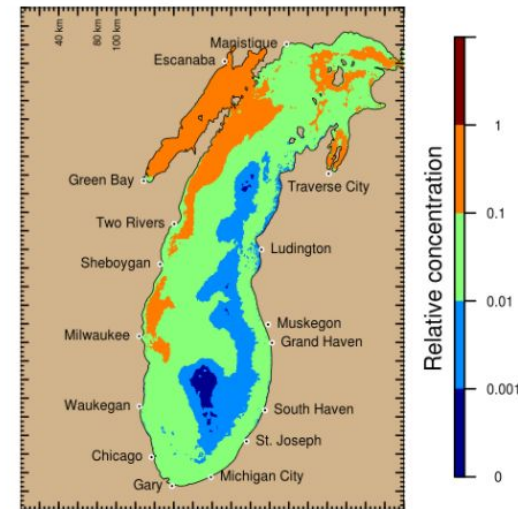
The project also provides information on various ecological situations and disturbances that are broadly applicable to management questions nationally and internationally.

Pothoven and Olds, *Journal of Freshwater Ecology*, 2020
 Pothoven, *Ecology of Freshwater Fish*, 2019
 Pothoven and Vanderploeg, *Journal of Great Lakes Research*, 2020
 Pothoven and Vanderploeg, *Fundamental and Applied Limnology*, 2017



Young of year whitefish from a seine haul.

Hatch 2020-06-14 Valid 2020-08-01
 Age 48 days



Experimental Larval Fish Dispersion Forecast for Lake Michigan CSMI 2020. These animations provide estimates of the transport of larval fish by currents in Lake Michigan from nearshore spawning regions. This information is intended to support field researchers during the Lake Michigan Cooperative Science and Monitoring Initiative (CSMI).

Examining the changing spatial structure of the food web for the development of scenario models and adaptive strategies for managing the system.

Research Questions:

What factors determine the spatial distributions of pelagic organisms?

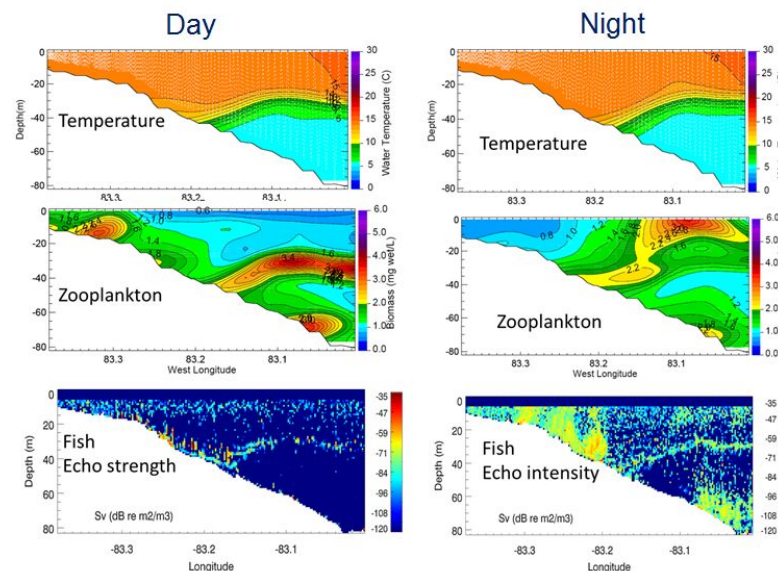
What are the effects of invasive species on food webs across spatial and temporal scales?

What are the spatial and temporal linkages between the lower food web, climate, lake physics, and fish recruitment?

Implications:

- Species distributions (and interactions) vary greatly between day and night and at fine spatio-temporal scales
- High frequency sampling needed to capture dynamics (eg. quagga veligers as prey source for larval fishes).

Day and night snapshot of a transect in Lake Huron near Thunder Bay captured by the GLERL Plankton Survey System (PSS) and fisheries acoustics.





Ecosystem Response to Invasive Species

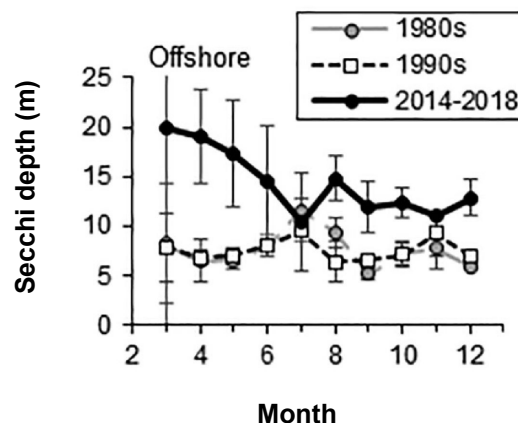
Ashley Elgin, Ed Rutherford, Rochelle Sturtevant

Invasive dreissenid mussels are ecosystem engineers that have altered multiple aspects of the Great Lakes.

Physical, chemical, and biological impacts:

- Increased water clarity and UV radiation
- Infrastructure fouling
- Altered nutrient cycling
- Shift in energy from the water column to lake bed
- Reduced spring diatom bloom
- Increased harmful and nuisance algae
- Zooplankton community changes
- Native mussel declines
- Declines of key native species
- Declines in fish condition and growth
- Enhanced avian botulism outbreaks

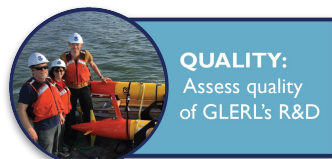
Water clarity has increased dramatically during spring—driven by quagga mussels.



Pothoven and Vanderploeg, *Journal of Great Lakes Research*, 2020

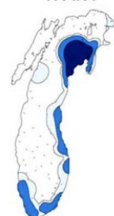


Collecting invasive quagga and zebra mussel samples in Lake Michigan.

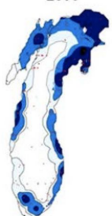


What is the status of invasive dreissenid mussels?

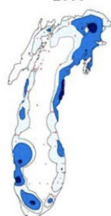
Zebra Mussels
1994/95



2000



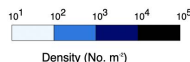
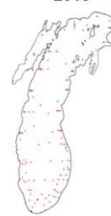
2005



2010



2015



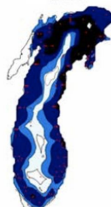
Quagga Mussels



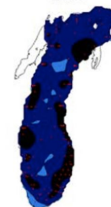
2000



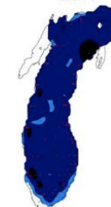
2005



2010



2015



NOAA Technical Memorandum GLERL-172

ABUNDANCE AND DISTRIBUTION OF BENTHIC MACROINVERTEBRATES IN THE LAKE HURON SYST BAY, 2006-2009, AND LAKE HURON, INCLUDING GEORGIAN AND NORTH CHANNEL, 2007 AND 2012.

Thomas F. Nalepa¹, Catherine M. Riseng², Ashley K. Elgin³, Gregory A. Lang⁴

STATE OF THE GREAT LAKES 2019

Technical Report

Journal of Great Lakes Research 46 (2020) 528–537



Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr



Long-term trends of Lake Michigan benthos with emphasis on the southern basin

Knut Mehler^{a,*}, Lyubov E. Burlakova^a, Alexander Y. Karatayev^a, Ashley K. Elgin^b, Thomas F. Nalepa^c, Charles P. Madenjian^d, Elizabeth Hinchey^e

^aGreat Lakes Center, Buffalo State College, 1300 Elmwood Avenue, Buffalo, NY 14222, USA
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^cWater Center, University of Michigan, 214 S. State St., Ann Arbor, MI 48106, USA
^dU.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI 48105, USA
^eU.S. EPA, GLNPO, 77 W. Jackson Blvd., Chicago, IL 60604, USA

Abundance and Biomass of Benthic Macroinvertebrates in Lake Michigan in 2015, with a Summary of Temporal Trends

Thomas F. Nalepa¹, Lyubov E. Burlakova², Ashley K. Elgin³, Alexander Y. Karatayev², Gregory A. Lang⁴, Knut Mehler²

- Quagga mussels have largely displaced zebra mussels
- Mussel density and biomass is highest in Lakes Michigan & Ontario
- Density has peaked in mid-depth zones, but continues to increase in deep regions (>90 m)

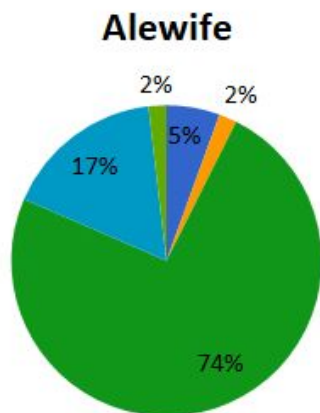
Data Sources: NOAA; Nalepa et al. 2014, 2017, 2018, 2020 GLERL Technical Memos Mehler, Elgin, Nalepa et al., *Journal of Great Lakes Research*, 2020



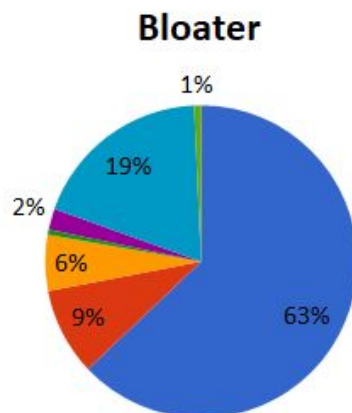
BUFFALO STATE
The State University of New York

Quantifying lower food web changes and evaluating implications for the Great Lakes fishery.

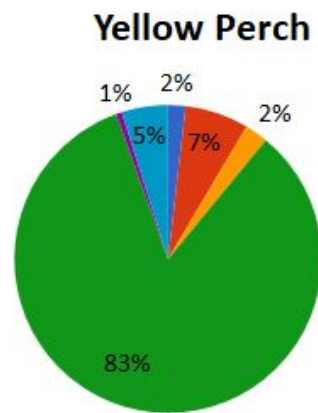
Dreissenid veligers now dominate diets of nearshore fish larvae, and larvae growth, survival and potential recruitment are reduced compared to pre-quagga years.



nearshore



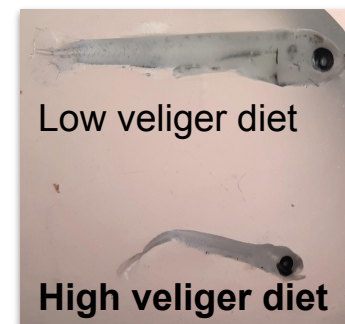
offshore



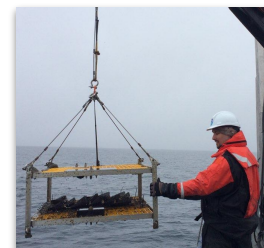
nearshore



Yellow Perch feeding expts



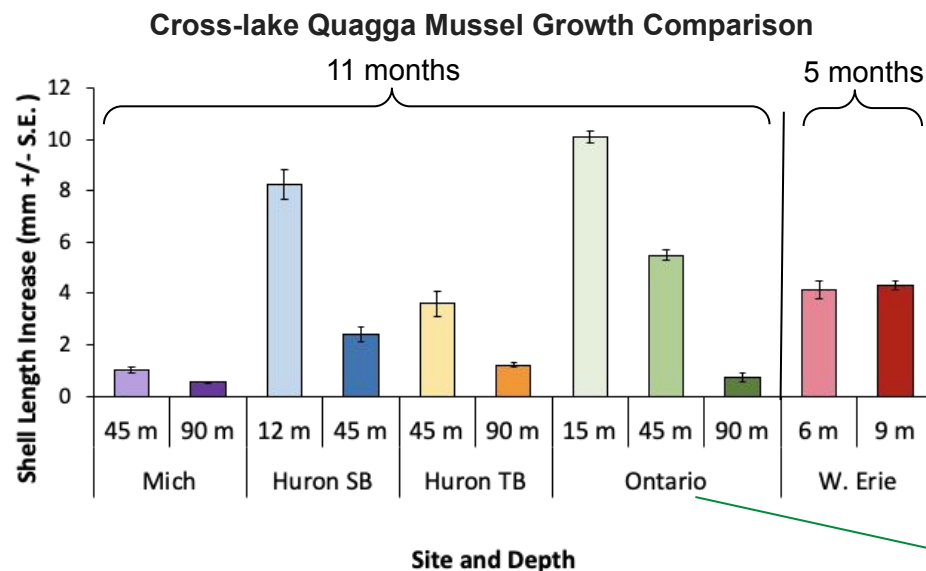
Invasive mussel growth experiments explore how environmental conditions affect mussel growth across the Great Lakes.



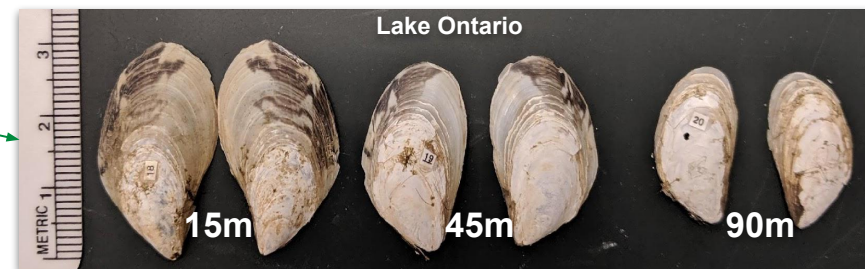
- Multi-year, cross-lake study.
- First study to quantify growth of quagga mussels at greater depths (90 m) and in these regions.
- Measured growth across all seasons.



Invasive mussel growth is influenced by depth, season, and regional factors.



- Depth has a strong impact on growth rate.
- Substantial growth occurs after fall turnover and during winter.
- Some regions with high growth potential also have high mortality and low background mussel density.
- Temperature and Chlorophyll data offer only a partial explanation for observed differences.

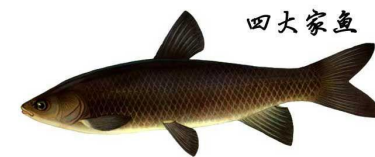
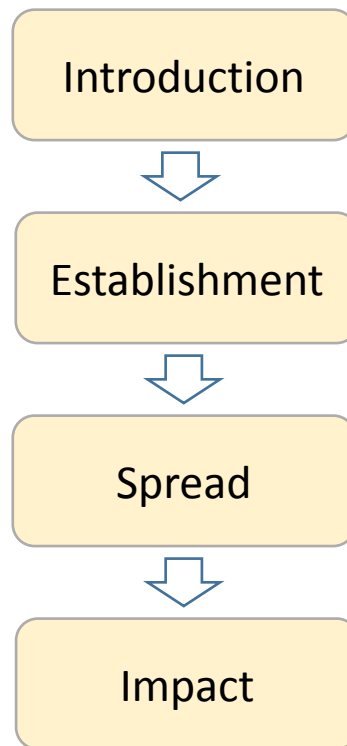


Elgin et al., *Journal of Great Lakes Research*, in revision

Projecting invasive species potential effects in the Great Lakes.

Steps to invasion . . .

- Introduction: Is there sufficient habitat for invasive carp in the Great Lakes?
- Establishment: Once in, can they reproduce and reach high biomass?
- Impacts: Once in and established, should we be concerned?



青鱼 *Mylopharyngodon piceus*



草鱼 *Ctenopharyngodon idella*



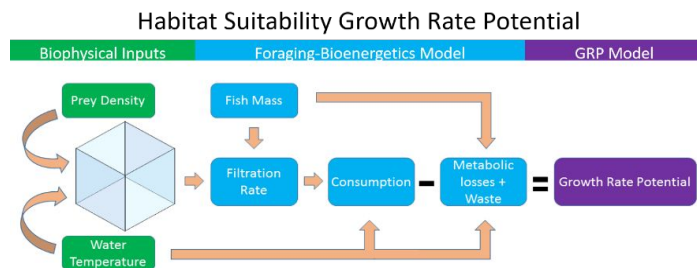
鲢鱼 *Hypophthalmichthys molitrix*



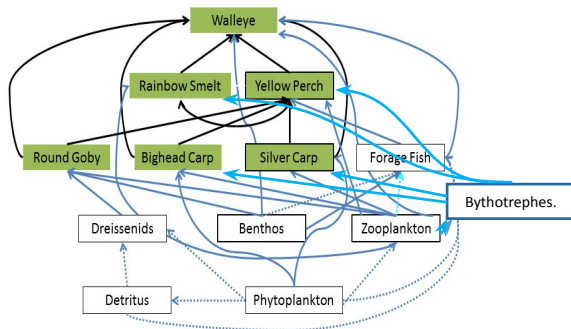
鳙鱼 *Hypophthalmichthys nobilis*

Applying different modeling approaches to evaluate potential effects of multiple stressors in the Great Lakes.

Introductions and Spread

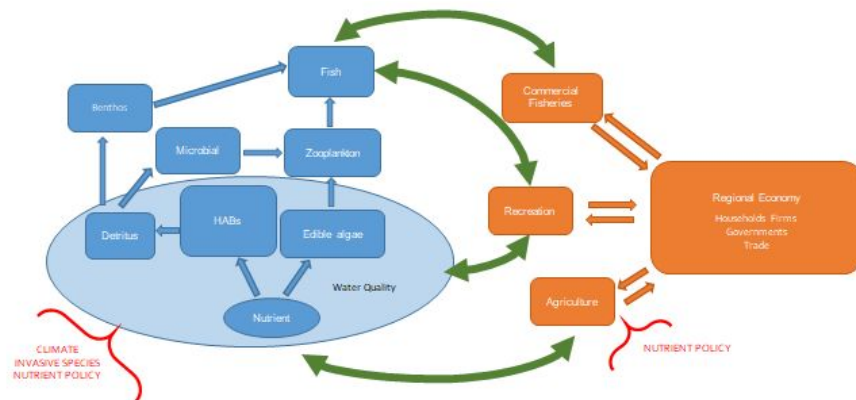
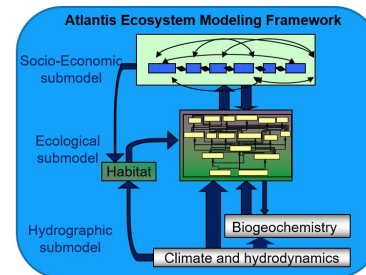
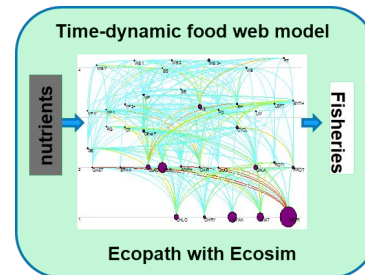


Establishment & Community Impacts



Individual Based Bioenergetics Community Model

Food web and Ecosystem Impacts



Coupled Food Web and Economic Models

Management challenge: potential establishment of invasive carp

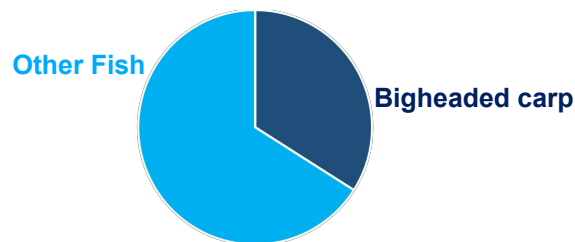
Invasive Carp biomass and food web impacts were predicted to be higher in productive habitats.

Impacts were mainly negative for macroplankton and planktivores, and positive for some piscivores.

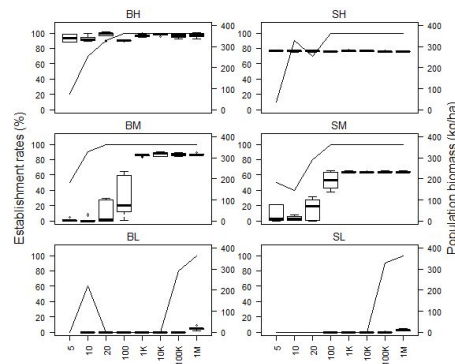
Predicted carp population growth and impact depended more on assumptions of high prey vulnerability than on assumed carp vulnerability to predators.

In productive lakes, such as Lake Erie, carp could make up as much as 1/3 of the total fish biomass.

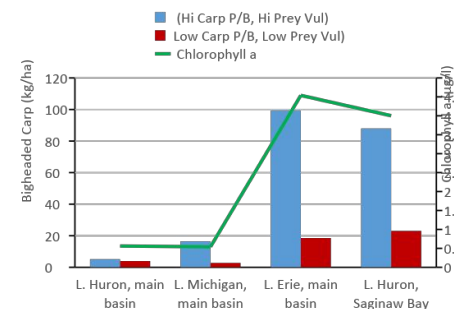
Carp could establish with a seed population of 5-10 individuals.



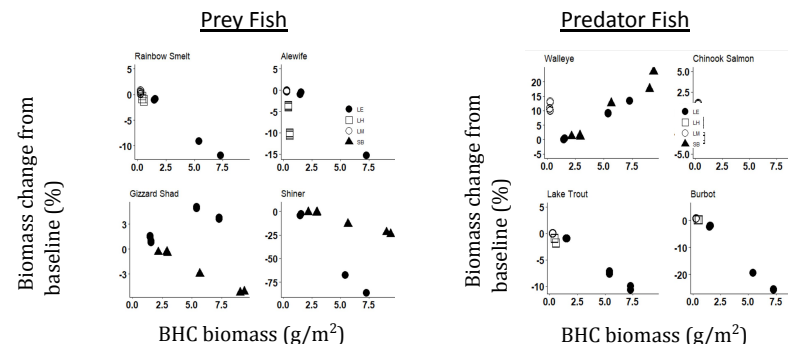
Bigheaded Carp Establishment



Bigheaded Carp Biomass

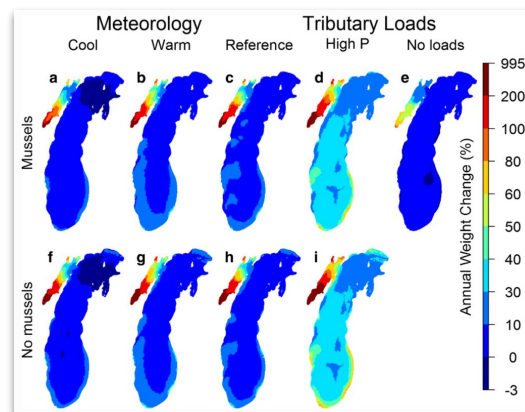


Winners and Losers

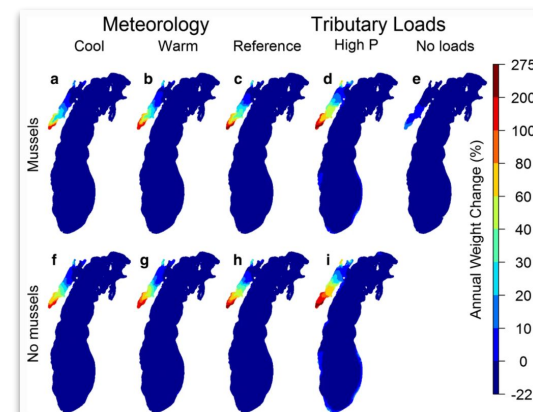


Modeling the consequences of invasive mussels, nutrient inputs, and climate on the potential for Bighead and Silver Carp (BHC) establishment in Lake Michigan.

- Mussels reduce BHC habitat quality but are an insufficient barrier to BHC establishment because their effects are limited in time and space.
- A warming climate will improve BHC habitat suitability by extending the growing season.
- The implications of a longer growing season is that migration corridors will be available longer, increasing the likelihood of spread, and enhance growth in food-rich habitats like Green Bay.
- Nutrient pollution is the most influential form of human activity (evaluated in this study) in determining BHC habitat suitability.

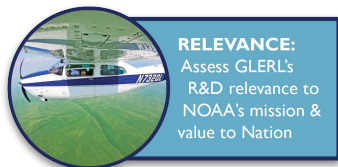


Bighead Carp *Hypophthalmichthys nobilis* annual growth (%) in all scenarios evaluated. Note that initial weight was 5480 g, and (c) represents the reference scenario (scenario 1, Table 1).



Silver Carp *Hypophthalmichthys molitrix* annual growth (%) in all scenarios evaluated. Note that initial weight was 4350 g, and (c) represents the reference scenario (scenario 1, Table 1).

Alsip, Rowe, Rutherford, Mason et al. in *Biological Invasions*, 2020.



Scientific Leadership: Leveraging research results and collaborations to address key Great Lakes issues.

Study: Asian carp could find plenty of food in Lake Michigan

A newly released study says if Asian carp reach Lake Michigan, would find enough food to spread farther

By JOHN FLESHER AP Environmental Writer
August 12, 2019, 2:42 PM • 4 min read



FILE - In this June 18, 2012, file photo, Asian carp, jolted by an electric current from a

Alsip et al. 2019



Alsip et al. 2020

Developing models to identify potential effects of invasive carps on the food webs in the Great Lakes.

These models are being used by federal and state agencies in invasive carps control efforts to minimize impacts on commercial and recreational fishing.

Working with Invasive Carp Regional Coordinating Committee.

> 450 news stories related to invasive carp manuscripts!

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS): A “one-stop shop” for information on aquatic nonindigenous species in the Great Lakes.

GLANSIS is:

- A Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) database.
- A NOAA project to enhance access to information on non-native species in the Great Lakes region.

GLANSIS provides:

- A simple interface for accessing Great Lakes specific content from the national (USGS NAS) database.
- Advances search capacity supporting research on the patterns and particulars of Great Lakes invasion biology.

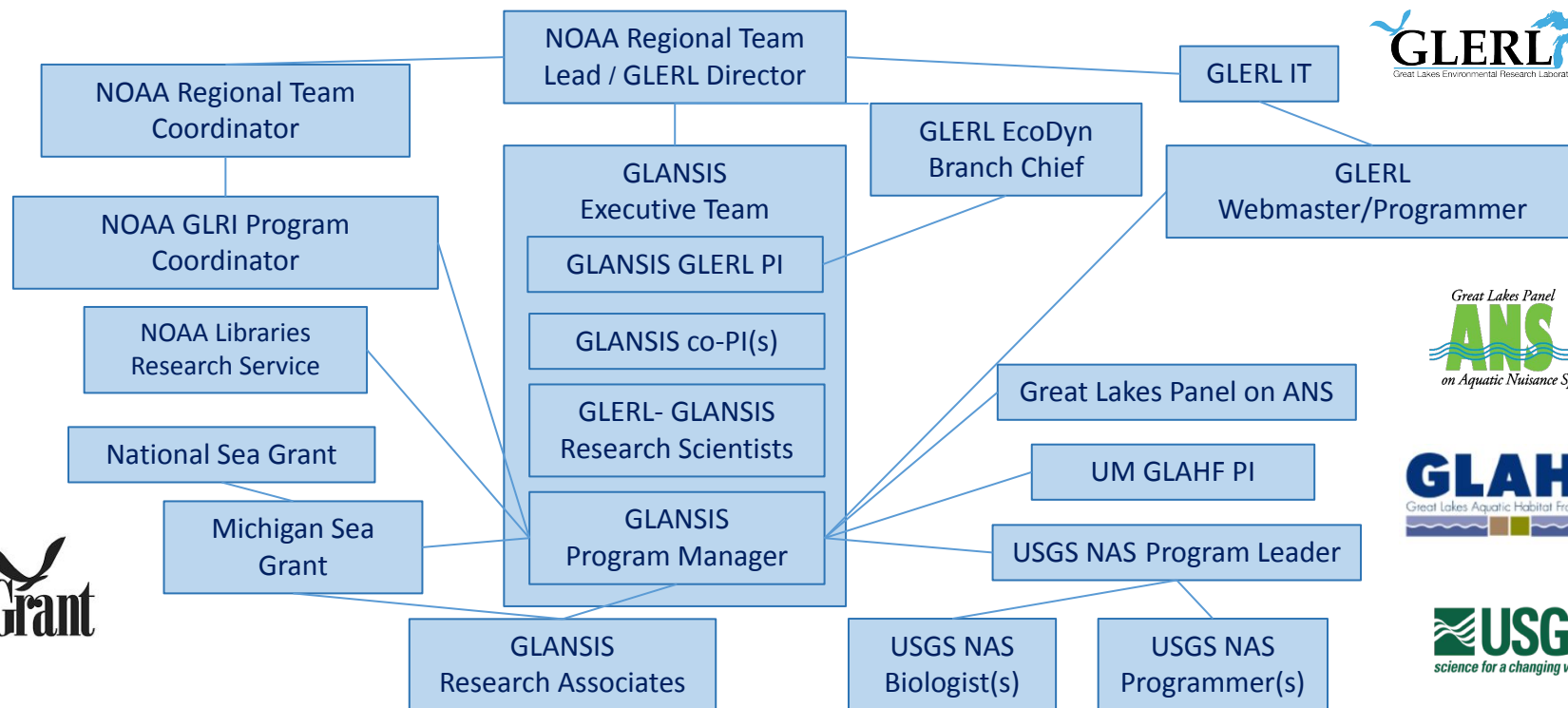
GLANSIS contains:

- Comprehensive profiles on each of the 187 non-native species established in the Great Lakes and more than 80 high risk potential invaders.
- Detailed collection of records for thousand of individual reports of non-native species in the Great Lakes.
- A Clearinghouse of risk assessments relevant to Great Lakes management summarizing more than 3000 individual species assessments by multiple state and federal agencies.





GLANSIS is a large inter-agency collaborative effort.





RELEVANCE:
Assess GLERL's
R&D relevance to
NOAA's mission &
value to Nation

GLANSIS provides key information for developing mitigation strategies for present and future Great Lakes aquatic invaders.

NOAA Technical Memorandum GLERL-108
An overview of the management of Great Lakes
Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

NOAA Technical Memorandum
A risk assessment of potential Great Lakes aquatic invaders
Alquist, Friesner, Lantry, Bouslog, Whitham, Conant, Buckley, Sturtevant, Edward Rutherford

2018 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"
El-Lewer, Nicholas Rutherford, Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

2019 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"
El-Lewer, Nicholas Rutherford, Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

STATE OF THE GREAT LAKES 2019
Technical Report
Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

Language: Understanding terminology nonindigenous species
Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

Alien language: Using controlled vocabulary to talk about invasive species
Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

GLANSIS
Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

Management of Biological Invasions (2018) Volume 9, Issue 3: 177-185
DOI: <https://doi.org/10.1016/j.biol.2018.03.010>
© 2018 The Author(s). Journal compilation © 2018 Elsevier B.V.
Open Access

Viewpoint
What it is to be established: policy and management implications for non-native and invasive species
Journal of Great Lakes Research
Volume 45, Issue 6, December 2019, Pages 1011-1035

Recent history of nonindigenous species in the Laurentian Great Lakes; An update to Mills et al., 1993 (25 years later)
R.A. Sturtevant, R.B. O'Meara, D.M. Mason, E.S. Rutherford, A.E. Elmer, J. Lower, F. Martinez

Development of a risk assessment framework to predict invasive species establishment for multiple taxonomic groups and vectors of introduction
Rutherford

A Review and Secondary Analysis of Competition-Related Impacts of Nonindigenous Aquatic Plants in the Laurentian Great Lakes
by R. Buckley, Sturtevant, Lantry, Bouslog, Whitham, Conant, Alquist, Friesner, Edward Rutherford

Management of Biological Invasions (2019) Volume 10, Issue 1: 192-199
Information Management
Interactive mapping of nonindigenous species in the Laurentian Great Lakes
Joseph P. Smith, E.K. Lower, Felix A. Martinez, Catherine M. Riseng, Lacey A. Mason, Edward S. Rutherford, Matthew Neilson, Pam Fuller, Kevin E. Wehrhahn, and Rochelle A. Sturtevant

GLANSIS
GREAT LAKES AQUATIC NONINDIGENOUS SPECIES INFORMATION SYSTEM
www.glerl.noaa.gov/glansis

The GLANSIS Website
The Website provides information and the resources necessary to:
• Identify and describe non-indigenous species
• Develop comprehensive policies for address multiple species and pathways
• Develop management strategies
• Develop risk assessment frameworks
• Develop and implement monitoring programs
• Develop and implement control programs

Some of the 150 152 154 157 Non-Native Species Established in the Great Lakes
Number of Known Aquatic Nonindigenous Species by Great Lakes Watershed



RELEVANCE:
Assess GLERL's
R&D relevance to
NOAA's mission &
value to Nation

GLERL food web expertise is sought to educate a worldwide audience.

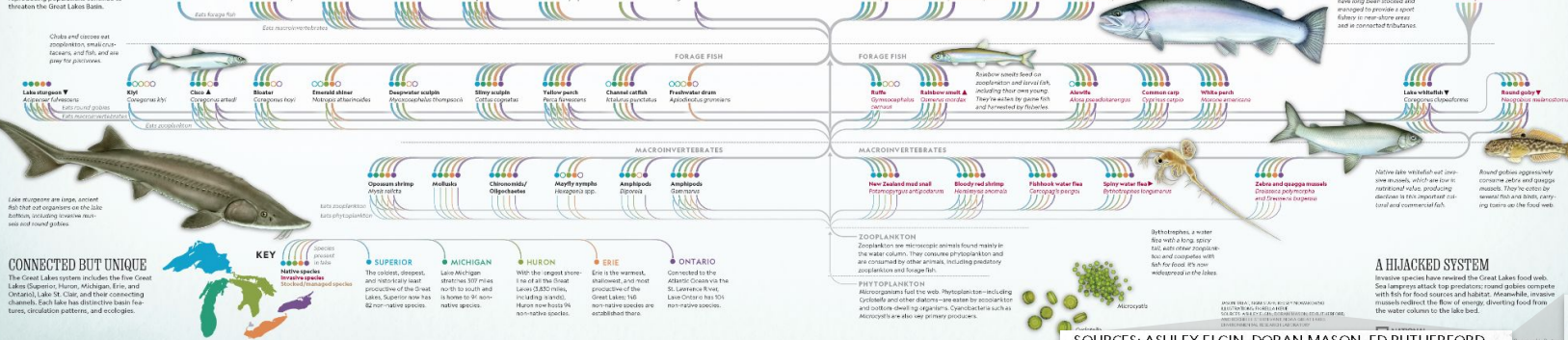
A FOOD WEB DISRUPTED

A thriving, complex food web is crucial to the health of one of Earth's largest surface freshwater ecosystems. But introductions and invasions of non-native aquatic plants and animals, the harvesting and stocking of top predator fish, and elevated nutrient and contaminant levels have scarred the Great Lakes food web, affecting fisheries, wildlife, and the health of the ecosystem.



THE LAKES TODAY

More than 180 non-native species with reproducing populations continue to threaten the Great Lakes Basin.



SOURCES: ASHLEY ELGIN, DORAN MASON, ED RUTHERFORD, AND ROCHELLE STURTEVANT, NOAA GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY



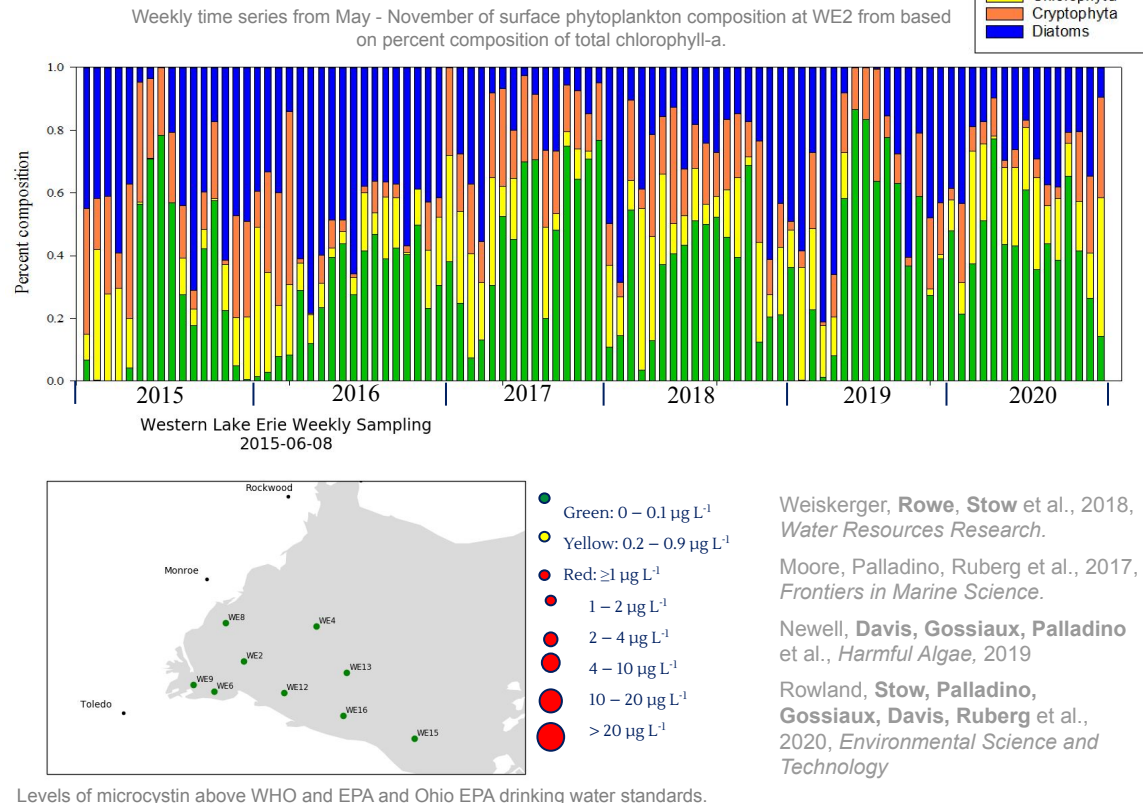
Ecosystem Response to Nutrient Inputs

Reagan Errera, Henry Vanderploeg, Casey Godwin, Mark Rowe, Ed Rutherford



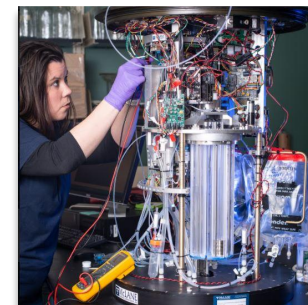
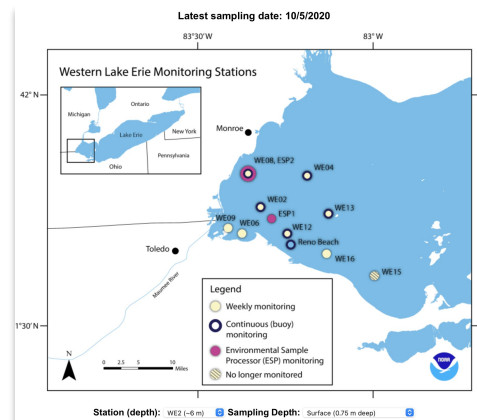
Water quality and HAB monitoring provides critical information to regional stakeholders.

- Fieldwork focuses on observing the size, movement, and toxicity of harmful algal blooms (HABs) in Lake Erie and Lake Huron (Saginaw Bay).
- Used to develop improved predictions of HAB transport, growth, and toxin levels, and our general understanding of HABs within the region.
- Long-term trends in HAB development, duration, extent, and termination.
- Provide weekly data on microcystins (algal toxins) to stakeholders, including drinking water managers, who rely on this information for water management decisions and the public.
- Supports NOAA in providing critical information to regional stakeholders via the Lake Erie HAB Forecast and models.



HABs field monitoring, buoy and sensor data assist in the development of tools to measure toxins and predict bloom size and movement.

- Data are collected continuously with buoys throughout the season as well.
- High frequency phosphate and nitrate measurement in addition to sonde and met.
- Helps evaluate internal cycling of phosphorus due to wave driven resuspension.
- Fills gaps between weekly sampling.
- GLERL and Great Lakes Observing System (GLOS) portals serve real-time data.



Environmental Sample Processor (top) and SeaTrac Autonomous Surface Vehicle (bottom), both of which GLERL uses to study HABs and monitor water quality.

Department of Commerce



Bronze Medal

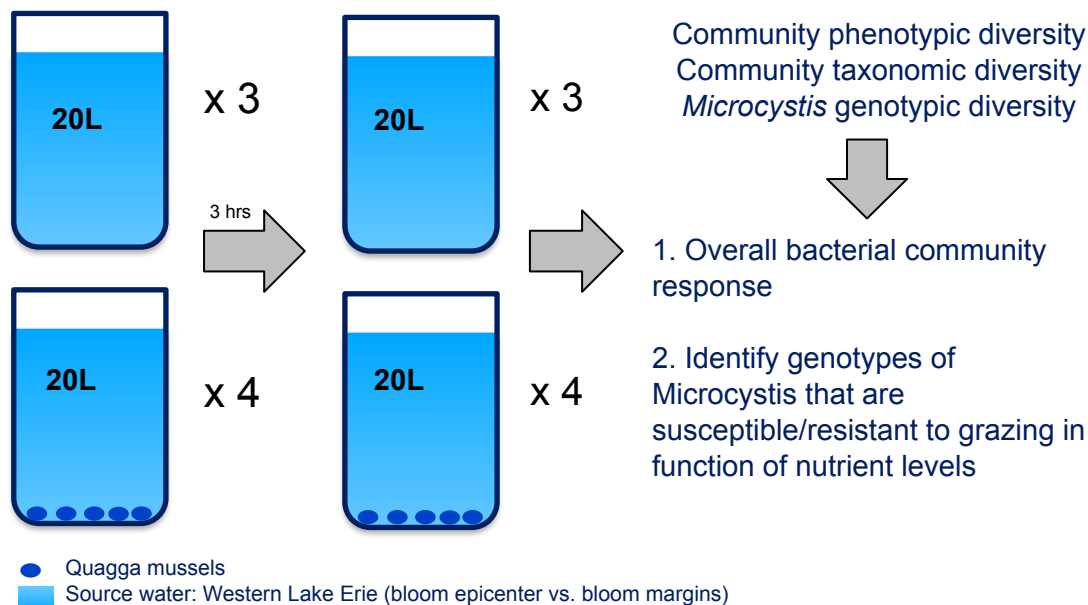
2016: Department of Commerce Bronze Medal: Response Activities for the Lake Erie Harmful Algal Bloom that Impacted Drinking Water Supplies in Ohio and Michigan.



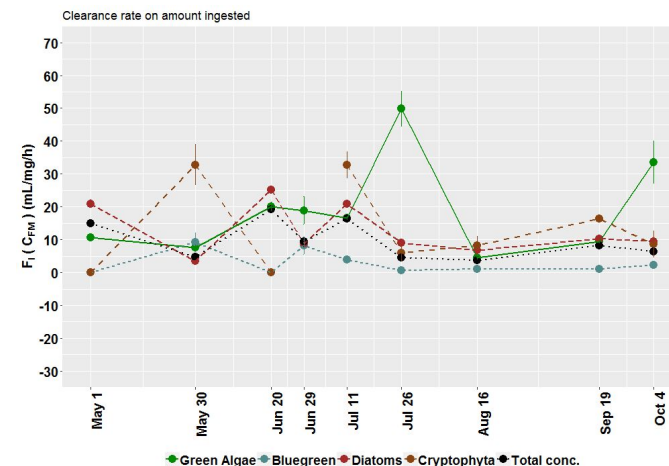
2019: President's Gears of Government Award: for significantly advancing rapid and remote detection of harmful algal bloom toxins.

Experiments on ecological mechanisms: The role of dreissenid mussels in transforming nutrient loads into harmful algal blooms.

Experimental design



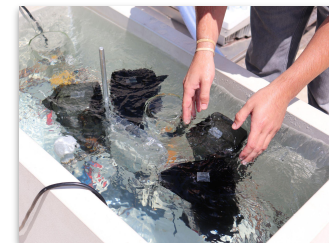
Feeding rate determined by FluoroProbe is one of many approaches to quantify feeding along with 'omics measures.



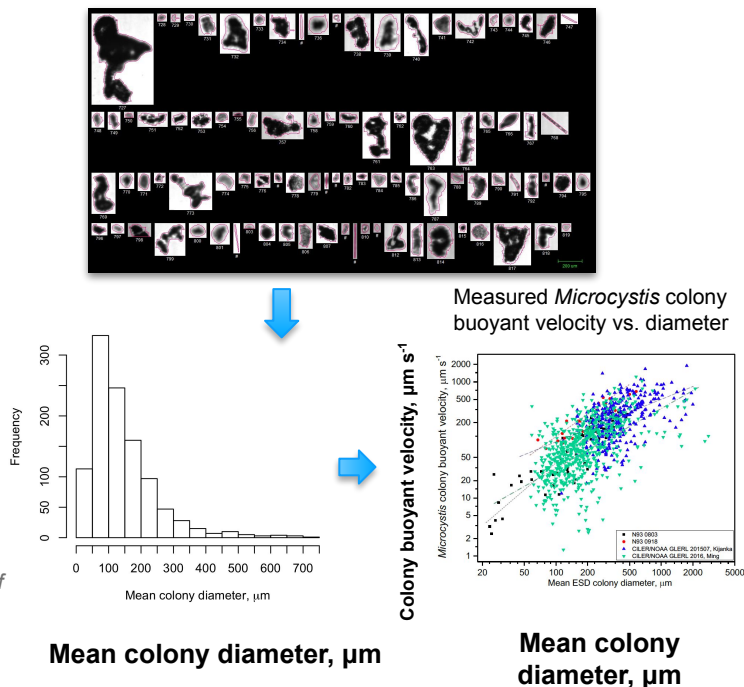


Experiments on ecological mechanisms: Measurement of *Microcystis* colony buoyancy and size distribution to improve HAB forecasts

- Diel vertical migration affects bloom distribution and transport.
- Small colonies are more responsive to light than large ones.
- Buoyancy can vary between lakes because of nutrient limitation.
- Information used to develop the Lake Erie HAB Forecast.

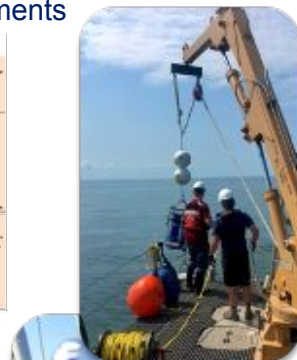


Conducting buoyancy experiments on *Microcystis* algae.

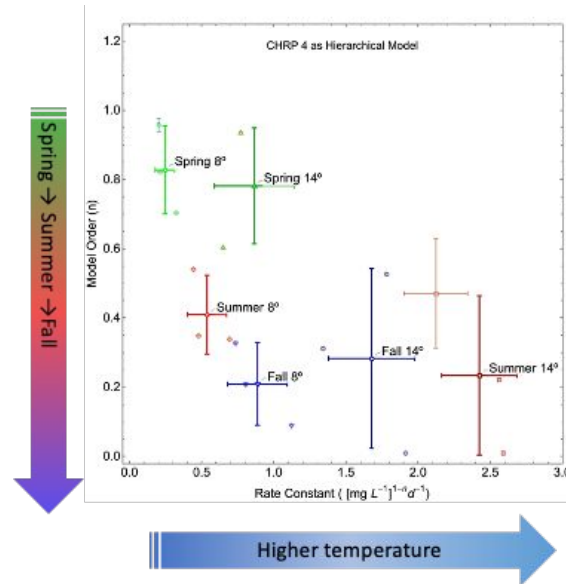


Den Uyl, P., **Rowe, Vanderploeg** et al., 2021 (in review), *Harmful Algae*.

Laboratory experiments and moored instruments both show that hypoxia triggers release of phosphorus from Lake Erie sediments

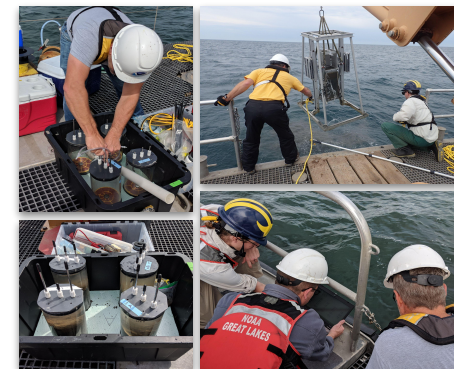
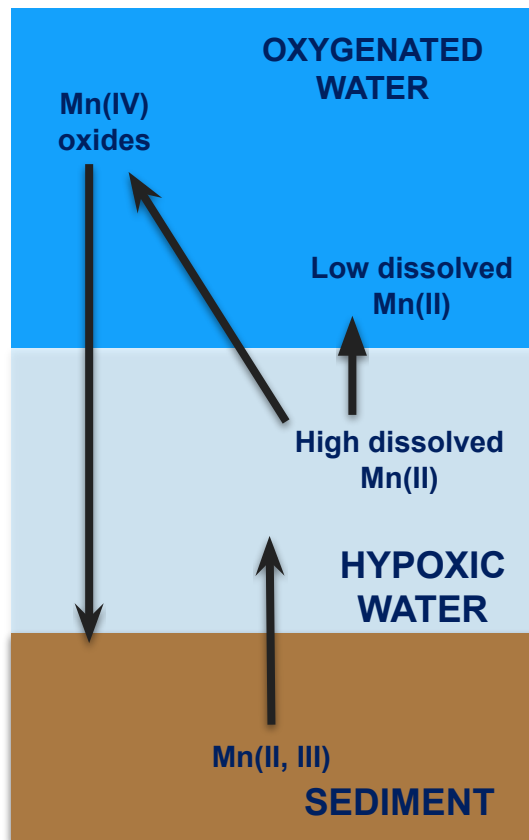


Fine-scale measurements of sediment oxygen demand help understand this key driver of oxygen depletion in summer



Applied biogeochemistry to understand effects of hypoxia on drinking water

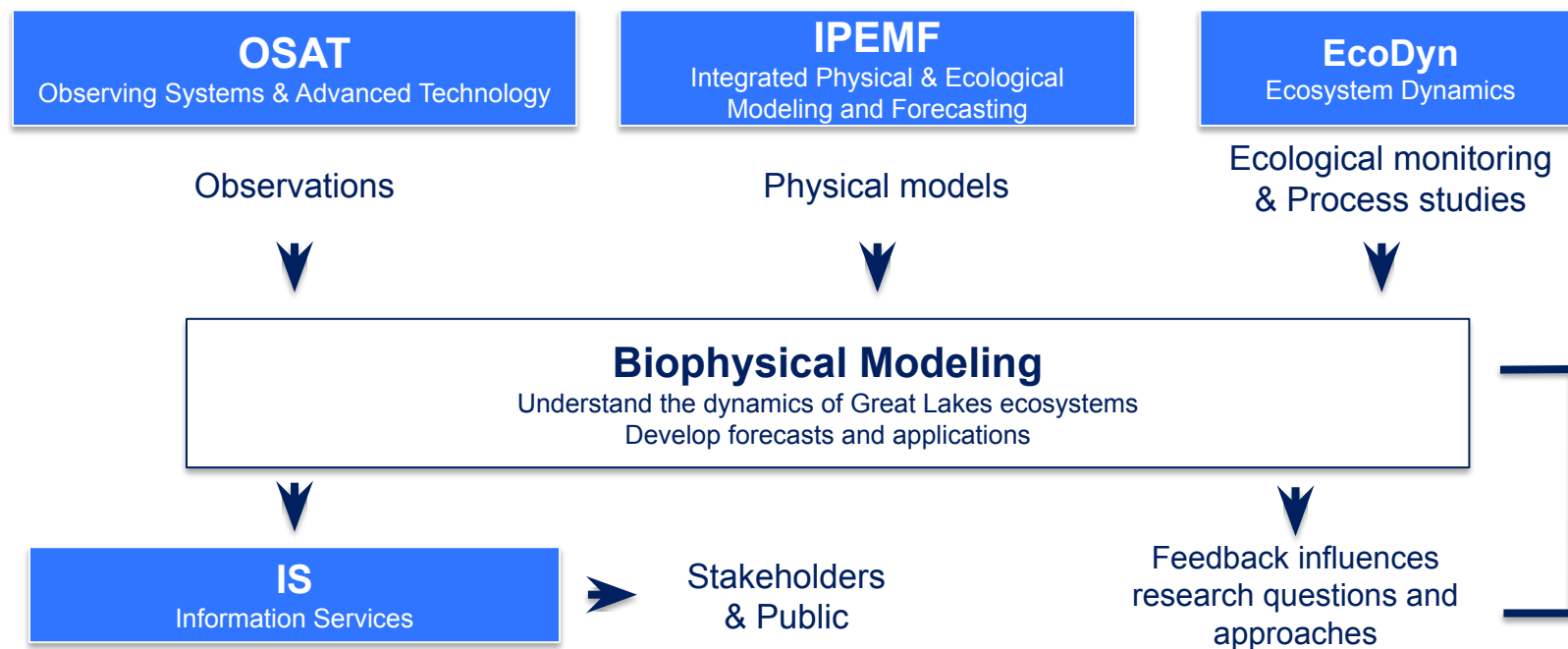
- Elevated manganese (Mn) requires additional treatment and, if not removed, leads to discoloration drinking water
- Release of Mn begins during hypoxia (around 2 mg L⁻¹ dissolved oxygen)
- Mn oxidizes slowly in Lake Erie and can persist for days as dissolved Mn



Collecting sediment and water samples from Lake Erie to learn more about the lake's oxygen levels and hypoxia events.



Biophysical modeling integrates and synthesizes information from each branch at GLERL.

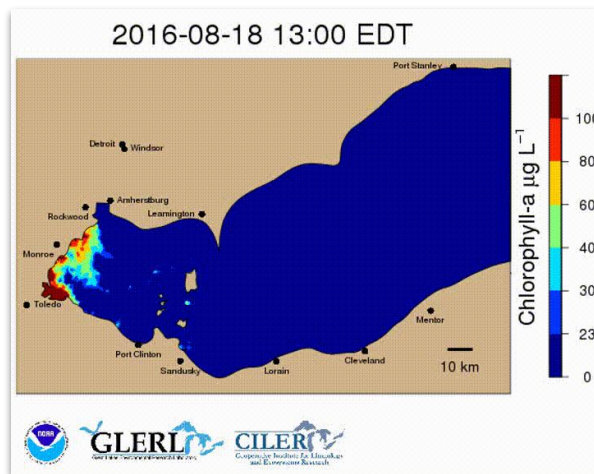




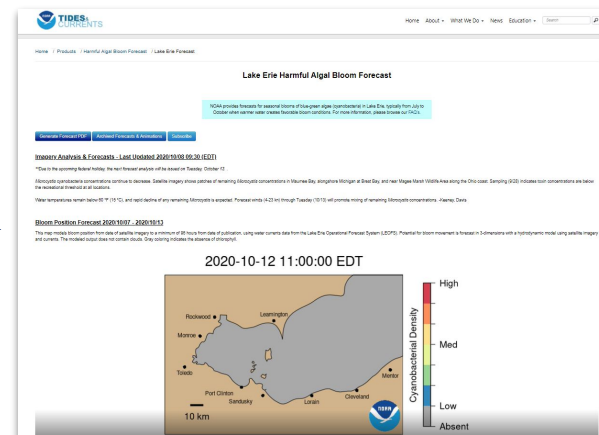
RELEVANCE:
Assess GLERL's
R&D relevance to
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value to Nation

Transition to operations: Lake Erie HAB Forecast provides water resource managers and the general public with actionable information.

- GLERL 3D HAB transport model transitioned to NOS in 2020.
- Stakeholder feedback assessments continue and will inform future system upgrades.



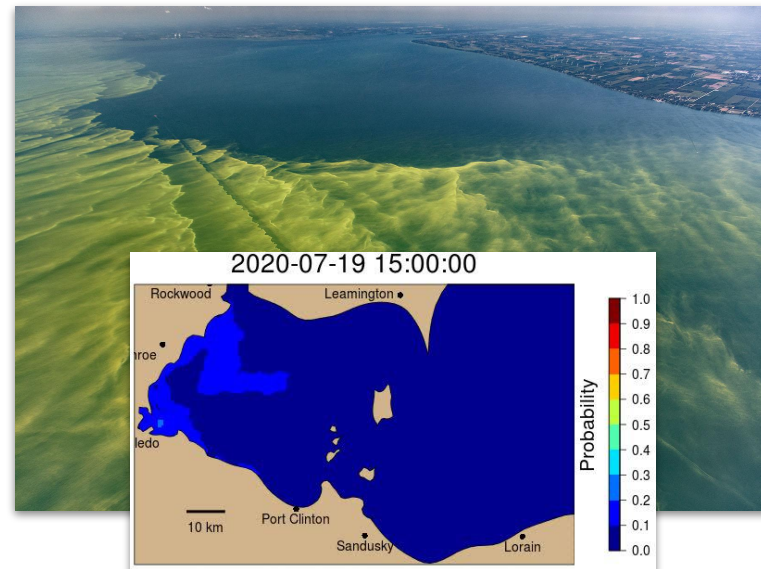
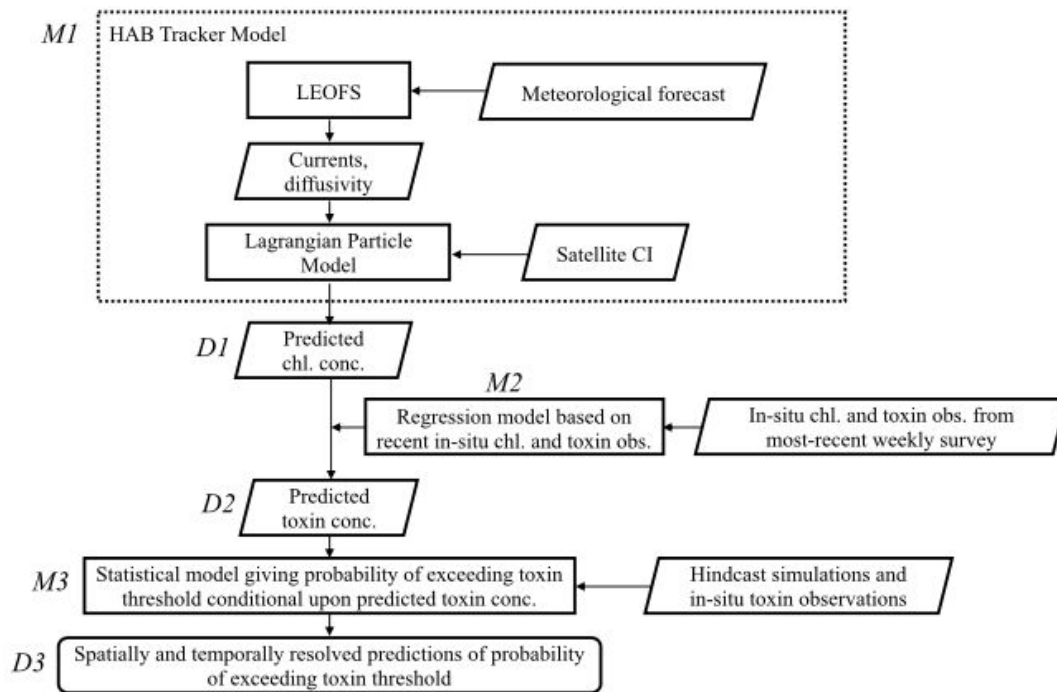
Rowe, Anderson et al., 2016, *J. Geophysical Research - Oceans*.



<https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/hab-forecasts/lake-erie/>

In support of NOAA's legislative mandate to develop and maintain operational forecasts to predict harmful algal blooms by the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA).

Looking forward: Experimental Lake Erie microcystin toxin forecast



Liu, Rowe, Anderson, Stow et al., 2020, *Environmental Modeling and Software*.

Lake Erie Hypoxia Forecast for Public Water Systems Decision Support

Developing an experimental dissolved oxygen forecast model for Lake Erie, coupled to an existing real-time, fine-scale hydrodynamic model.

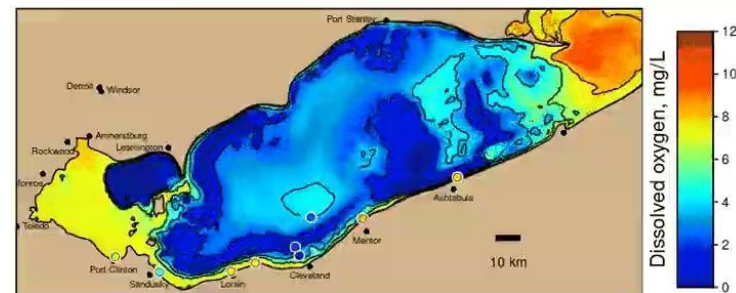
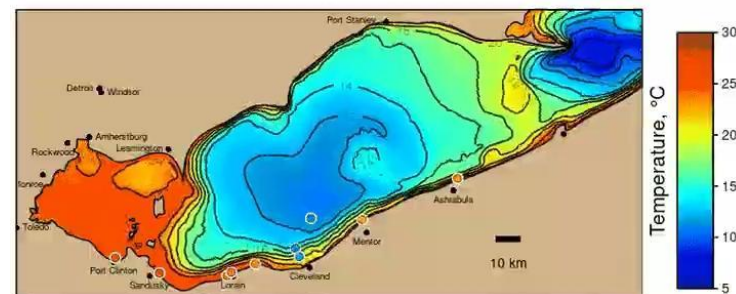
The experimental forecast gives public water systems advance warning of lake circulation events that are likely to cause changes in raw water quality and allows drinking water managers to prepare when conditions that promote hypoxic water movement into the vicinity of water intakes occur.

Models are an extension of the existing, next-generation Lake Erie Operational Forecasting System that GLERL transitioned to operations at NOAA's National Ocean Service Center for Operational Oceanographic Products and Services in 2016.

Authorized by the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), 33 U.S.C. §4001–4009, Funded by NOAA NCCOS Coastal Hypoxia Research Program.

Sat 22 Aug 2020 05:00 EDT

2020-08-22 09 GMT



Rowe, Anderson, Stow et al., 2019, *Journal of Geophysical Research: Oceans*

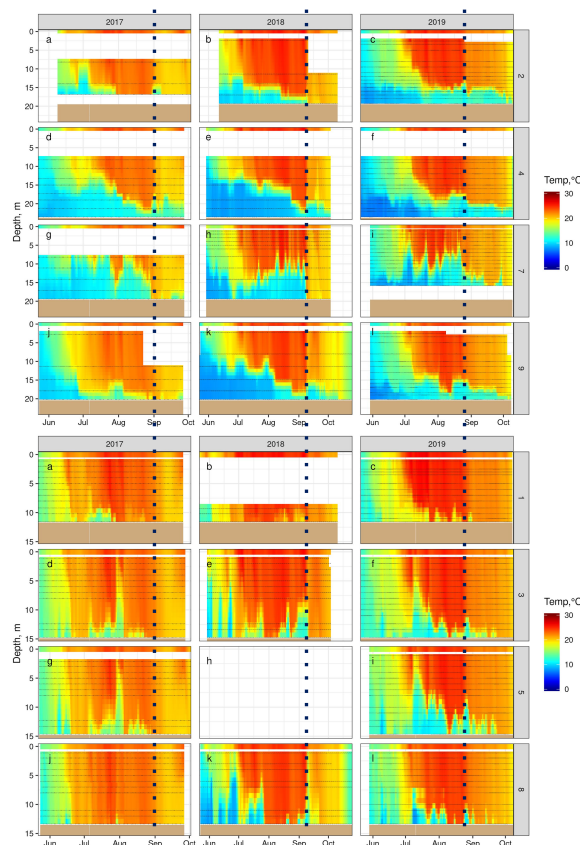
Funding: NOAA NCCOS Coastal Hypoxia Research Program

Temperature and dissolved oxygen sensor moorings provide data necessary for understanding hypoxia events.

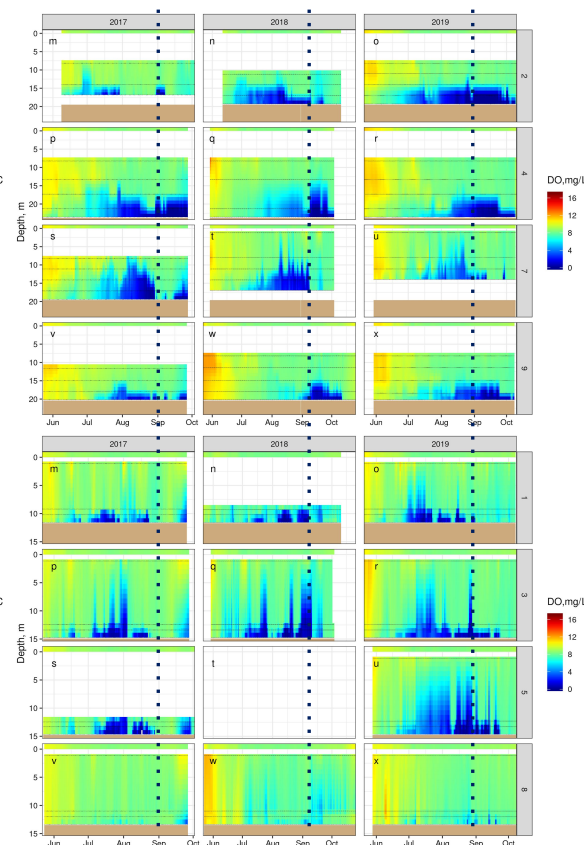
- Supports development of the Lake Erie Hypoxia Forecast.
- Designed to observe 3D dynamics of the central basin thermal structure and hypoxic zone.
- Novel observations of early initiation of hypoxia along the Ohio shoreline in July, associated with tilting of the thermocline by dominant southwesterly winds.
- Coastal upwelling events associated with northeasterly wind events.

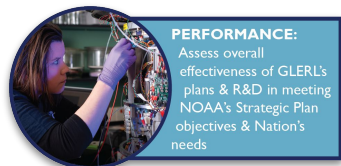
Data available through National Centers for Environmental Information (NCEI):
<https://doi.org/10.25921/qd27-bj97>

Temperature



Dissolved oxygen





Lake Erie Hypoxia Forecast: Assessment of utility to stakeholders

Focus group study with public water system manager documented changes in stakeholder knowledge and behavior after three years interacting with the experimental forecast:

- Increased knowledge of hypoxia
- Increased use of the forecast in operations
- Increased use of the forecast in communications

Water treatment plants can be prepared for changing conditions.

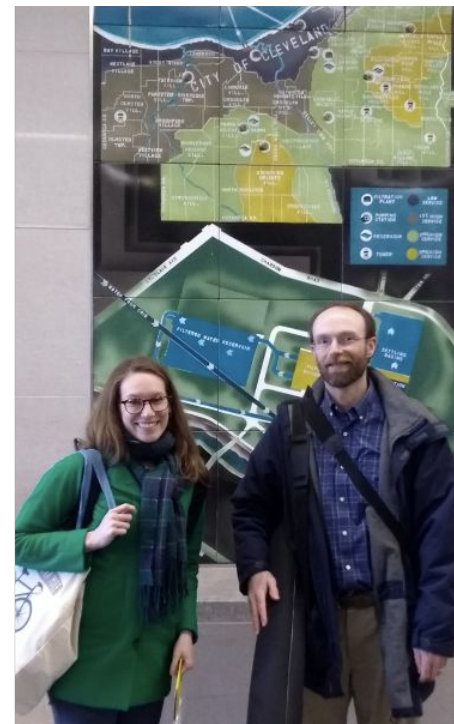
“You don’t have a lot of time to react when it happens [hypoxic water intrusion]. When I saw it, it was like *snap* that. The temperature just falls and the pH falls out. “

“We would be better prepared. We could let the operators know that this could happen...maybe run some extra monitoring or pay more attention to current monitoring. If we know something is coming, we can check our chemicals to make sure that we’ve got enough in stock.”

Enables quick response to changing conditions.

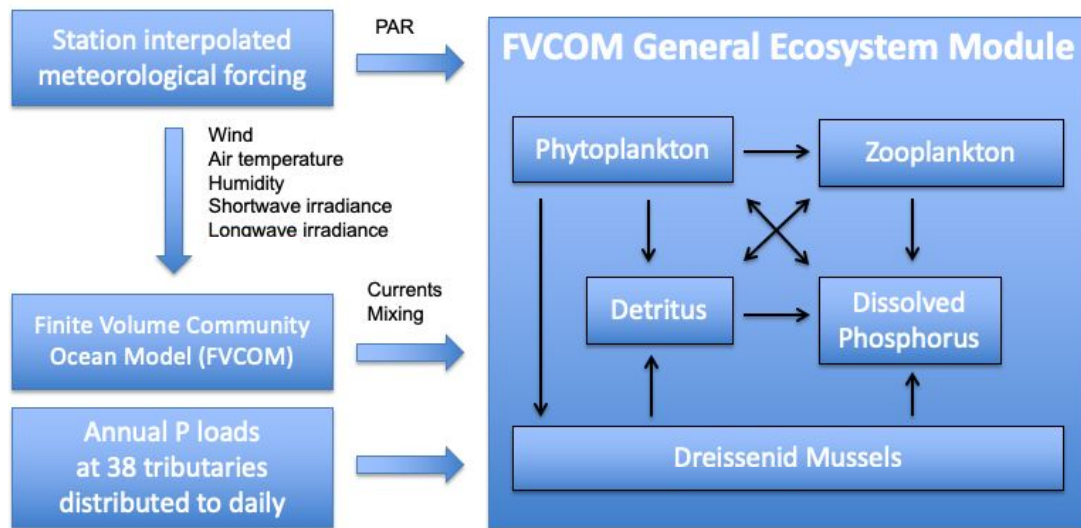
“The sooner we catch any changes, the smaller the corrections you have to make to your treatment.”

For more on this project, watch the “Preventing a Great Lakes Drinking Water Crisis” video on the review website.

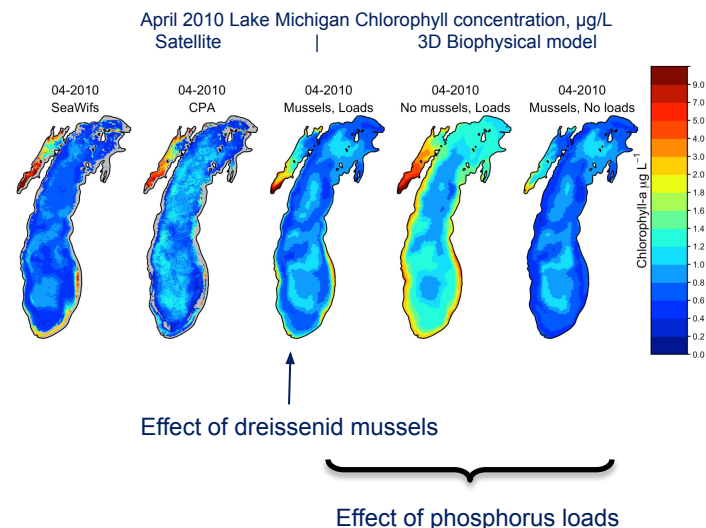


Devin Gill, Stakeholder specialist with CIGLR, and GLERL Researcher Mark Rowe conducted a focus group study with public water systems over a four-year period to gain insights on how the Experimental Hypoxia Forecast benefits users.

Biophysical model quantifies the impacts of invasive mussels, nutrient inputs and climate on the productivity of Lake Michigan.



Dolan and Chapra. 2012, *J. Great Lakes Res.*
USGS gages



Improving sustainable land management decision making at the sub-watershed level by targeting nutrient loading and land use practices that impact Great Lakes endpoints.

Objectives:

- Identify sources of nutrient loading that cause ecosystem impacts in coastal areas
- Evaluate costs/benefits of management in priority basins
- Community Engagement in Targeted Watersheds



TIPPING POINTS
& INDICATORS

Supporting Sustainable Communities in Great Lakes States

Tipping Point Planner to support LAMP
and community planning decisions

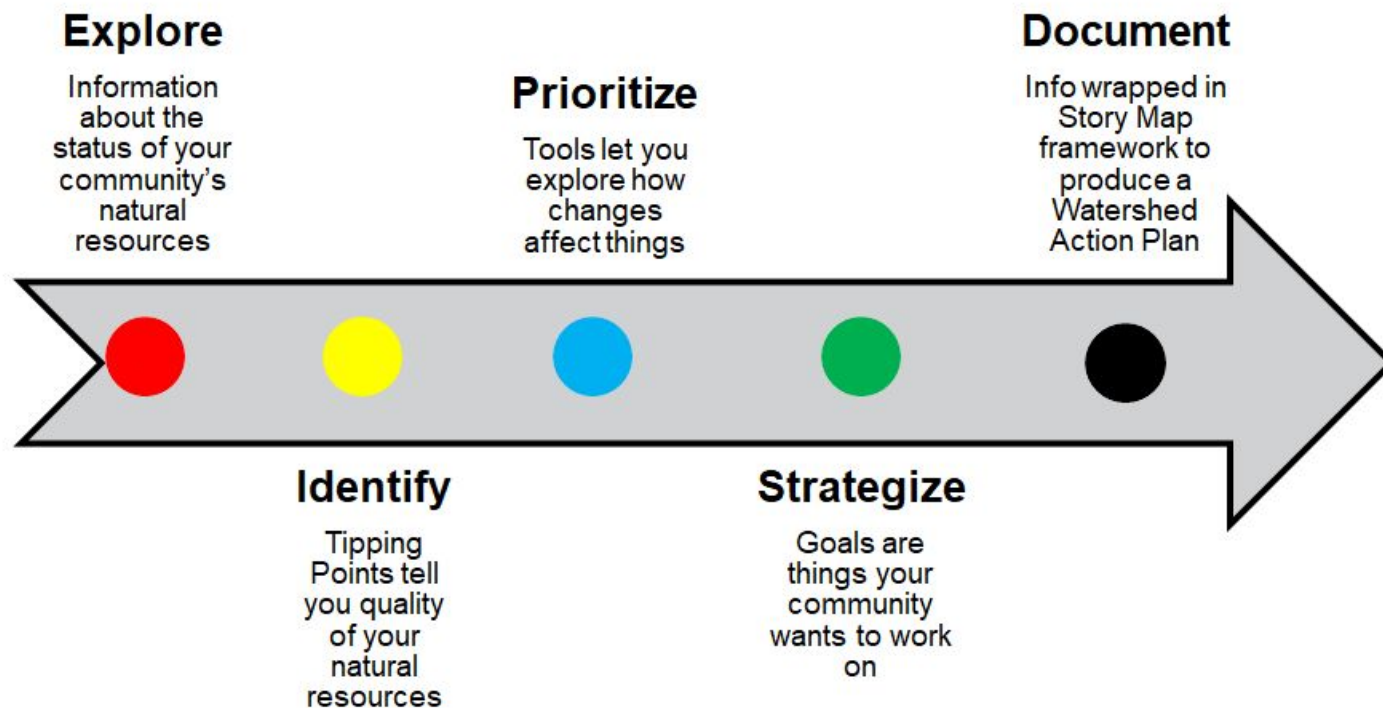
Ed Rutherford¹, David Hyndman², Anthony Kendall², Sherry Martin², Quercus Hamlin², Bryan Pijanowski³, Lydia Utney³, Dan Walker³, Brian Miller³, Tomas Höök^{3,4}, Kara Salazar^{3,4}

¹NOAA GLERL, ²Michigan State University, ³Purdue University, ⁴Illinois Indiana Sea Grant

www.tippingpointplanner.org



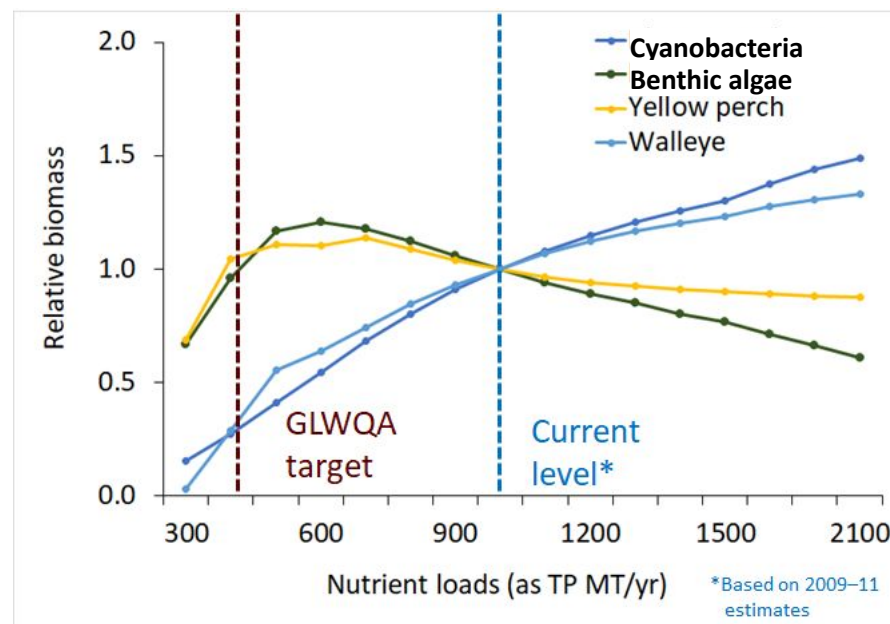
Tipping Point Planner decision support system components



Watershed land use and stakeholder decisions affect nutrient inputs to coastal waters, affecting water quality and fisheries.

- Historically, water quality, not fisheries, is used to set Great Lakes nutrient targets mandated under Great Lakes Water Quality Agreement.
- Increased nearshore eutrophication and offshore oligotrophication now require food web model projections.
- Nutrient targets for water quality (Cyanobacteria, nuisance algae) and fisheries (walleye, yellow perch may not be compatible).

Modeled Nutrient Tipping Points for Saginaw Bay, Lake Huron food web



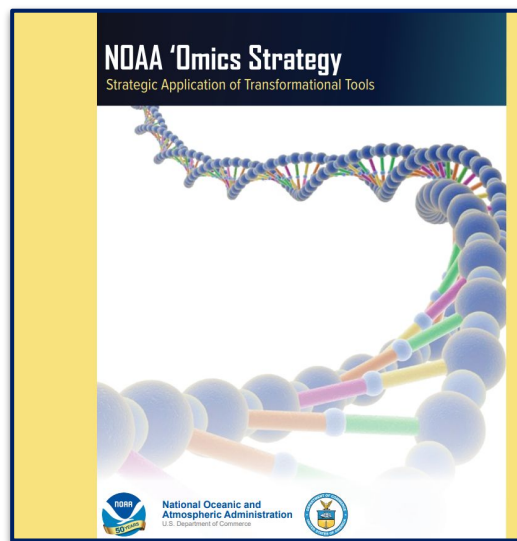
Kao et al., 2014. *Journal of Great Lakes Research*



Advanced 'Omics Tools to Understand Ecosystem Function

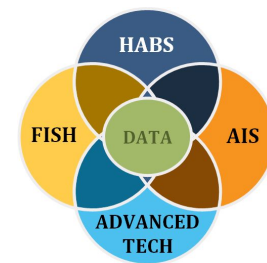
Reagan Errera

‘Omics provides new capabilities to monitor, understand, and model food webs, ecosystems, invasive species and HABs.



GLERL’s ‘Omics Mission

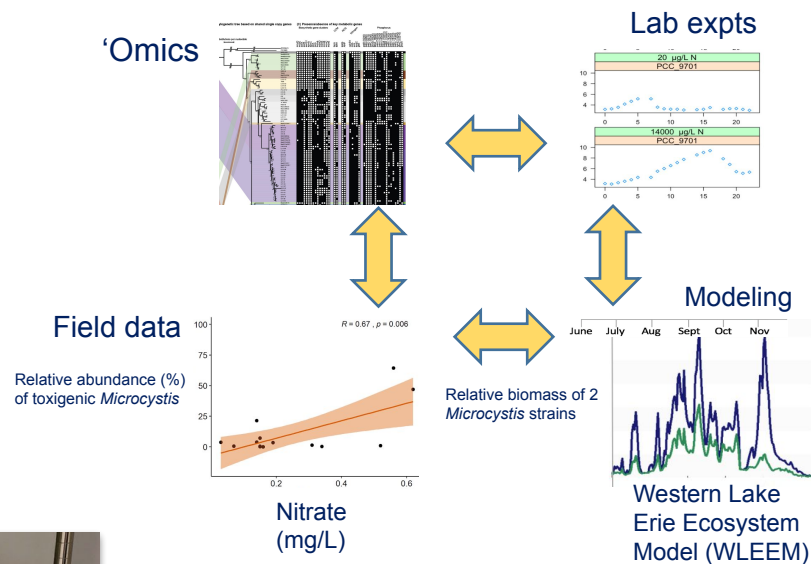
Use the multidimensional approach that ‘omics tools provide to study ecosystem change and develop monitoring tools and technologies specifically targeting harmful algal blooms, food web dynamics, invasive species, and fisheries, while providing essential data and techniques to our stakeholders.



See Supporting Documents on review website.

Linking genes to microbial traits key to the rise and demise of cyanobacterial harmful algal blooms.

- Isolation of 26 new strains of *Microcystis* from Lake Erie;
- Experiments to define traits linked to growth and death;
- Identifying key traits for each strain, including toxin production, toxin profiles, and growth rates (based on different nutrient regimes and oxidative stress);
- Define key parameters for biophysical models, forecasts;
- Compare model output to field observations.



Schmidt et al., 2020 *Harmful Algae*

Dick, Errera, Vanderploeg et al., 2021, *Environmental Microbiology*

Yancey et al., 2021 (Manuscript in preparation)



Advancing autonomous 'omics sampling for early detection of potentially toxic blooms.

- Third generation environmental sample processor (3G-ESP) programmed to detect toxin in near real-time and collect coincident archival samples for DNA analysis to characterize cyanobacterial community.
- Features a surface plasmon resonance sensor chip designed to target phycotoxins (targeted metabolites)
- Targeted 'Omics distinguishes toxin-producing from non-toxin producing cyanobacterial blooms
- May improve short-term toxin forecasting

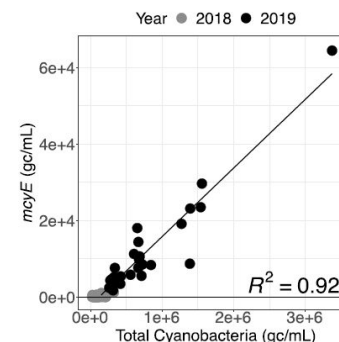
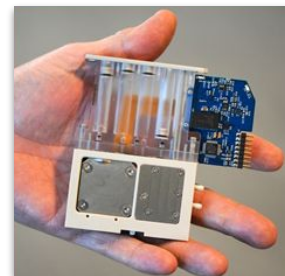


Reagan Errera, Steve Ruberg, and the 3G-ESP carousel which houses 60 cartridges for a mix of in-situ and archival samples.



MBARI Long Range AUV Tethys (top) acted as a scout for ESP/LRAUV Makai (bottom). Post recovery 2019 aboard NOAA R4108.

'Lyse & Go' sample cartridge for in-situ and archival samples.



Relationship between the toxin gene (mcyE) and total cyanobacteria biomass during the 2018 and 2019 blooms.

Den Uyl et al. 2021, *Environmental Science and Technology*, in review; Birtch et al. 2021, in prep



Looking Forward

Reagan Errera, Doran Mason, Ed Rutherford, Ashley Elgin

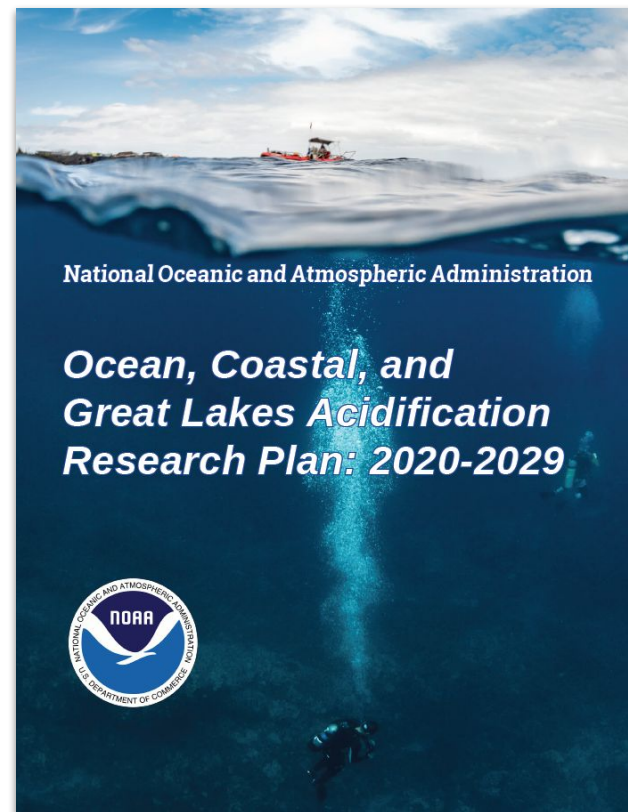
**Great Lakes Acidification
Food Web Response to HABs, Aquatic
Invasive Species, & Climate Change
Winter Limnology**

Looking forward: Great Lakes acidification

Great Lakes acidification has received relatively less research attention than ocean acidification (OA).

Acidification within the Great Lakes has the potential to influence the frequency and intensity of harmful algal blooms (HABs), disturb the food web, and impact the productivity of recreational and commercial fisheries.

- Increase monitoring of OA parameters;
- Research the influence of OA on HABs & inform short-term forecasts and longer-term scenarios;
- Increase our understanding the sensitivity of invasive mussels, plankton, fish, and other biota to OA;
- Incorporate carbonate chemistry into biophysical and food web models;
- Engage the public and stakeholders;
- Evaluate economic and social impacts of ecological outcomes or mitigation actions.





Looking forward: Upper trophic level response to harmful algal blooms and multiple interacting stressors (invasive species, hypoxia, climate change)

Conduct a cross-ecosystem comparison to assess and quantify food web and fisheries response to HABs, invasive species, hypoxia, and climate change.

General research questions:

- Are there changes in the abundance and spatial distributions of pelagic nekton (fish and invertebrates) in response to HABs, presence of toxins, and the interactive effects of other stressors?
- How do changes in the 3-D spatial distribution of organisms affect trophic interactions?
- What does this mean for the fishery?

Study Locations: western basin Lake Erie, eastern Gulf of Mexico (w/ NOAA Atlantic Oceanographic and Meteorological Laboratory)

Looking forward: Winter Limnology

- The Great Lakes are experiencing higher water temperatures and declines in ice cover.
- Key knowledge gaps about winter limit our understanding and ability to manage the Great Lakes.
- A CIGLR Winter Limnology Summit and *Journal of Geophysical Research: Biogeosciences* article identify priority questions in the areas of physics, chemistry, and biology:

JGR Biogeosciences

REVIEW ARTICLE
10.1029/2021JG006247

Special Section:
Winter limnology in a changing world

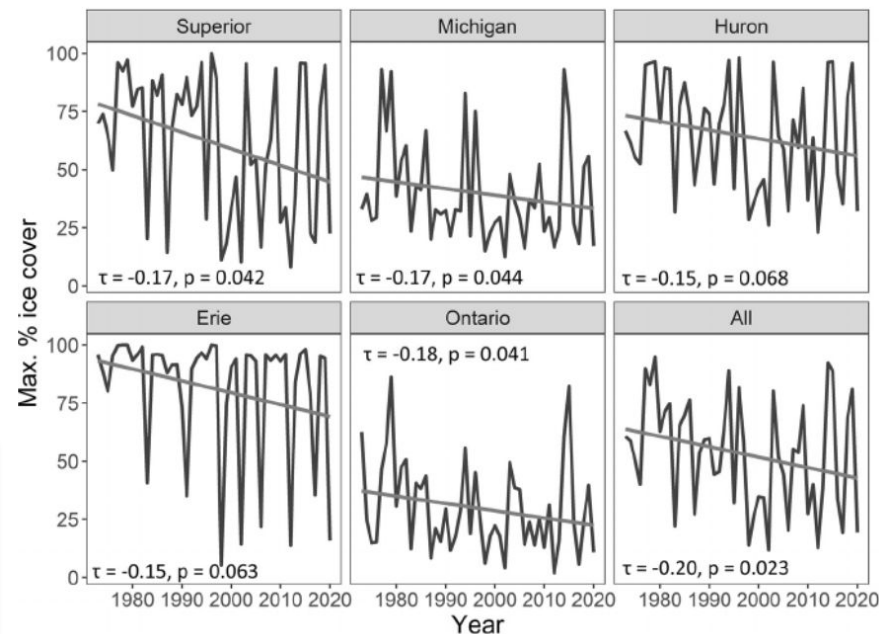
Key Points:

- Winter limnology is a key knowledge gap that limits understanding and management of the Great Lakes and

The Changing Face of Winter: Lessons and Questions From the Laurentian Great Lakes

Ted Ozersky¹, Andrew J. Bramburger², Ashley K. Elgin³, Henry A. Vanderploeg⁴, Jia Wang⁵, Jay A. Austin³, Hunter J. Carrick⁶, Louise Chavarie⁷, David C. Depew⁸, Aaron T. Fisk⁹, Stephanie E. Hampton⁹, Elizabeth K. Hinchey¹⁰, Rebecca L. North¹¹, Mathew G. Wells¹², Marguerite A. Xenopoulos¹³, Maureen L. Coleman¹⁴, Melissa B. Duhaime¹⁵, Ayumi Fujisaki-Manome¹⁶, R. Michael McKay¹⁷, Guy A. Meadows¹⁸, Mark D. Rowe⁴, Sapna Sharma¹⁹, Michael R. Twiss²⁰, and Arthur Zastepa²





Maximum ice cover has been declining in most Great Lakes over the last several decades.



EcoDyn is lead by an award-winning researcher.

2019 NOAA Distinguished Career Award: Dr. Henry Vanderploeg

For research contributions and leadership leading to a greater understanding of Great Lakes ecology throughout 44 years of dedicated service to NOAA.

2021 International Association for Great Lakes Research (IAGLR) Lifetime Achievement Award: Dr. Henry Vanderploeg

For important and continued contributions to the field of Great Lakes ecological research throughout his career.



**Congratulations
Henry Vanderploeg**

IAGLR's 2021
Lifetime Achievement
Award Winner



Summary

Hank Vanderploeg





In summary, EcoDyn . . .

Makes long-term ecological observations, conducts targeted use-inspired fundamental research on ecological processes, and provides data to develop models critical to understanding ecosystem structure and function.

Conducts laboratory and field experiments that support the development of new concepts, models, forecasting tools, and applications, increase the knowledge of the Great Lakes, and support resource management and public awareness.

Develops ecosystem models to forecast the effects of stressors and management options.

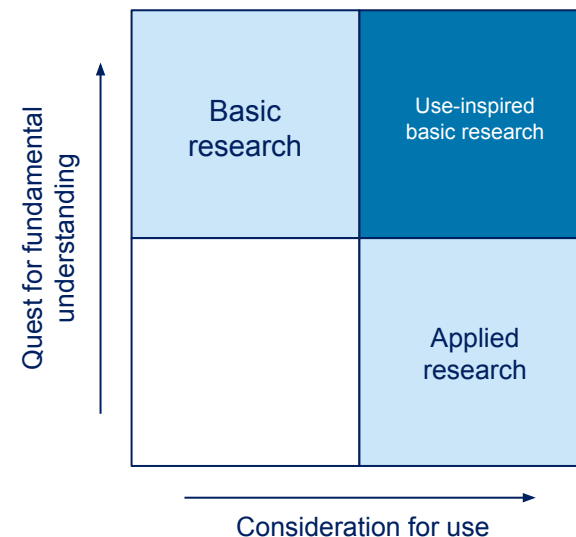


EcoDyn works to achieve NOAA's mission by. . .

Serving the larger goals of ecosystem understanding and forecasting.

Completing whole research chain necessary to promote mission-oriented products: Observations → Experiments → Concepts → Models/Applications.

Pushing the boundaries of fundamental science in service of mission needs.



Stokes, D.E. (1997) Pasteur's Quadrant



Thank you for your attention!

NOAA Federal

Henry Vanderploeg
Joann Cavaletto
Lyndsie Collis
Ashley Elgin
Jeff Elliott
Reagan Errera
Dave Fanslow
Paul Glyshaw
Duane Gossiaux
Doran Mason
Danna Palladino
Steve Pothoven
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Rochelle Sturtevant

**Cooperative Institute for
Great Lakes Research**

Casey Godwin
Peter Alsip
Ashley Burtner
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Glenn Carter
Subba Rao Chaganti
Paul Den Uyl
Michael Fraker
Deanna Fyfe
Holly Kelchner
Christine Kitchens
Timothy Maguire
Nathan Marshall
Kelly McCabe
Freya Rowland
Anna Schmidt
David Wells
Michele Wensman



Thank you for agreeing to serve as a member of the GLERL five-year science review panel!

We look forward to talking with you during the live Q & A sessions.

Review criteria:

Quality: The merit of our research and development within the scientific community.

Relevance: The value of our research and development to users beyond the scientific community.

Performance: The effectiveness and efficiency with which our research and development activities are organized, directed, funded, and executed.

Review week highlights:

- In-depth Q&A/discussions of the overview presentation each theme presentation.
- Meetings with GLERL stakeholders.
- Meetings with GLERL leadership and new staff.

All supporting documents can be found on the GLERL 2021 Review website at:

www.glerl.noaa.gov/review2021/#documents